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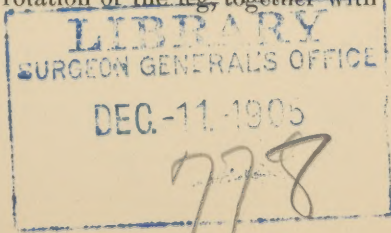
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THE DIRECT TRANSPLANTATION OF MUSCLES IN THE TREATMENT OF PARALYTIC DEFORMITIES.

BY JOEL E. GOLDTHWAIT, M.D.,
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THE fact that the tendons of non-paralyzed muscles can be attached to the tendons of those which are paralyzed, with a marked improvement in the usefulness of the part as well as correcting or diminishing existing deformities, has been definitely proved. During the past three years, since careful attention has been given to the subject, quite a large number of cases have been treated by different surgeons with very generally good results. Personally, of the thirty cases which have come under my care, the improvement, with one or two exceptions, has been very decided.

Until a year and a half ago these operations had been confined entirely to the reattachment of muscles which had distinct and well-formed tendons; but as the results in these cases were so gratifying it was natural to try the same principle in other parts in which the mechanical conditions were similar, although the anatomical structures were unlike. It was found in a large number of cases of infantile paralysis, in which the thighs were involved, that the sartorius and the tensor vaginæ femoris frequently escaped the otherwise general paralysis. The latter, because of its small size and the limited range of its contractility, is of comparatively little importance either in producing or for use in correcting deformities. The former, however, is different; naturally a long and strong muscle, with its spiral position, and the fact that between its distal and proximal attachments are two large joints, it is evident that, if not properly antagonized, it can produce undesirable results. The outward rotation of the leg, together with



the flinging gait so often seen in infantile paralysis, is largely the result of the action of this muscle. The ilio psoas, and some of the deep rotators, do, of course, play a part; but from the better attachment, mechanically, the sartorius is undoubtedly the most important.

Normally, when the other muscles of the thigh are present, the sartorius by its contraction causes flexion, abduction, and outward rotation of the thigh and also to a limited degree extension of the knee. In its normal position, resting as it does upon the strong anterior group of thigh muscles, it (the sartorius) in the middle of the thigh is raised at least an inch from the femur, so that in its contraction the quadriceps acts as the fulcrum over which the power of the sartorius is applied. It is this position or elevation of the sartorius upon the quadriceps that makes it possible for it to act as an extensor of the knee.

When, however, the muscles are affected as they are in poliomyelitis (acute anterior) the mechanical conditions change. The quadriceps extensor, instead of being an inch or more thick, becomes so much atrophied that it is represented by a thin fascia. The sartorius, as the result of this, practically rests upon the femur, and in changing its position it not only sinks down against the bone, but is drawn further backward on the inner side, so that as the result it crosses the femur nearer the upper part of the thigh than is normal.

In the new position, together with the absence of the muscles which normally antagonize it, the sartorius by its contraction causes an increase in the normal amount of flexion, abduction, and outward rotation of the thigh, and at the knee, instead of causing extension, it becomes a flexor. This can readily be demonstrated by having the patient sit upon a table so that the legs from the knees hang freely. Upon contraction of the sartorius, with the flexion and rotation of the thigh, which is expected, the foot and leg are drawn backward, not forward, this being the most conspicuous part of the movement.

It is obvious from this that with the muscle so situated its presence is in part a disadvantage, and as far as the control of the knee is concerned it would have been better had it been involved in the otherwise general paralysis.

About two years ago I described an operation at a meeting of

the Boston Orthopedic Club, and later showed a patient at the Surgical Section of the Suffolk District Medical Society in Boston, in which the sartorius muscle was transplanted and attached to the quadriceps extensor just above the patella. When the operation was first planned it was with the hope that by giving this muscle, which normally possesses considerable strength, a better mechanical attachment, the undesirable deformity would be corrected and the usefulness of the leg increased.

Since that time I have operated upon five patients for this purpose. In three the result has been a marked improvement; in two the result was a disappointment, the failure probably being due to imperfect methods of attaching the muscles. With the more perfect technique and with greater experience such failures should not result.

Of the three successful cases, one, a grown woman twenty years of age, has at the present time absolutely the normal amount of extension of the leg at the knee as contrasted with an entire inability to extend the leg before the operation. When sitting she is able to straighten one leg and hold it straight (thus supporting all of the weight of the leg) quite as well as the other. Upon standing, at the present time, the patient is able to bear all of the weight of the body on the lame leg, without artificial support, the sartorius being strong enough in its new position to hold the joint stiff. Before the operation, there being no power in the extensors of the thigh, no weight could be borne upon the leg unless the knee was fixed in a brace or supported by some artificial means. The flail, flinging gait, which was the only possible method of locomotion, has been entirely corrected, the leg being extended normally when the step is taken. The patient is, of course, still somewhat lame, but the lameness is due chiefly to the weakness of the foot and ankle, the mechanical difficulty at the thigh having been almost entirely corrected. No apparatus for the thigh is now necessary, and the patient has been employed doing regular housework for the past eight months. The paralysis in this case had existed since early childhood, and previous to the operation she had been dependent upon the constant use of a cane or crutch.

In the second of the three successful cases the result will, I think, be quite as good as in the previous case. The patient, a

boy, twelve years of age, was first seen in consultation with Dr. C. S. Millet, of Brockton, and at that time there was complete paralysis of all of the muscles below the right knee, and no power in any of the anterior thigh muscles, except the tensor vaginae femoris and the sartorius. On sitting with the legs hanging, extension of the leg at the knee was impossible, as was also standing without support. On walking the thigh was rotated and the leg flung along.

When last seen, about five months after the operation, extension through almost the normal limit was possible. On sitting the leg could be straightened completely, but the muscle was not strong enough to hold it fully extended for more than a moment. There has been such a steady improvement in his condition, however, that I feel sure the sartorius will strengthen enough to give quite as useful a leg as in the former case.

The flinging gait with the rotation of the leg has been entirely corrected.

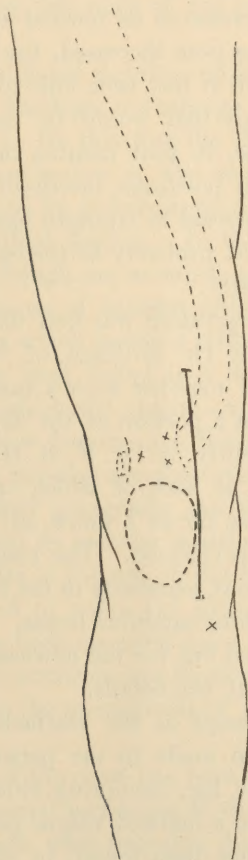
The third case, a girl eight years of age, had infantile paralysis of the right leg. All of the anterior muscles of the lower leg were completely paralyzed, and the anterior thigh muscles were much weakened, although they responded somewhat to voluntary effort. There was not enough power in the quadriceps, however, to completely extend the leg when the child was sitting.

The operation was performed about one year ago, with the idea of using the sartorius to help the weakened quadriceps. The result in this case has been a very decided improvement, the gait is better and the extension of the leg is likewise improved.

This in some ways was a more favorable case, and the result is not so striking as in the two just reported.

The operation is shown in the illustration, and consists in making a longitudinal incision about six inches long on the inner side of the thigh, so that the middle of the incision is opposite the top of the patella. Through this the sartorius muscle is dissected out and cut off at the extreme lower end, where it is attached to the tibia (x). This is then brought forward and attached to the muscular fascia just above the patella and a little to the inner side. The attachment must be made very firmly, and to accomplish this the fascia should be split and the muscle drawn through this so that it

becomes adherent to both the outer and the inner surfaces. For sutures, kangaroo-tendon is by far the best material ; catgut is not strong enough, and is absorbed too quickly, while silk cuts out (one failure apparently being due to this). The wound should be completely closed, and the whole thigh tightly bandaged with a



compress bandage, with the idea of preventing the contraction of the muscles so far as possible. Over this a plaster-of-Paris bandage or a long splint should be applied to control the motion of the knee-joint. The patient should be kept lying down for two weeks, at least, all attempts at sitting or even raising on to the elbows being

avoided, so as to relieve the strain upon the thighs. Gentle motion at the end of three weeks should be commenced, and the plaster entirely omitted at the end of from five to six weeks.

The course of these cases after the operation has been interesting. Theoretically, from the histological structure of the sartorius muscle (made up as it is of long, slender, parallel fibres), one would expect comparatively little increase in its normal strength or size; nevertheless, as the work has been increased, the strength of the muscle has increased also until it has been able to do quite perfectly the work of the quadriceps that would be required in walking or standing. In one case, in four months the circumference of the thigh, measured in two positions, increased one-half of an inch. This development or increase in strength has taken place, however, more slowly than would probably be the case in muscles with the fibres arranged differently.

About the time the operation was first described a similar operation was performed by Dr. Milliken, of New York City. This case has been reported together with a case in which an attempt was made to transplant a portion of the deltoid. Besides this, a case operated upon recently by Dr. F. B. Harrington, and another by Dr. G. C. Dolliver, at both of which operations I was able to be present, constitute, so far as I know, all the operations of this kind which have been performed. The results are most encouraging, and the improvement, especially in the first case here reported, has far surpassed my most sanguine hopes. The failures probably would not have occurred but for the newness of the operation and the lack of perfection of the details.

The only other attempt at the reattachment of the muscles directly which has been made by me personally, is a case of infantile paralysis of the leg, involving chiefly the anterior tibial muscle, and resulting in a marked valgus position of the foot.

In similar cases it has been found, in attaching the tendon of the peroneus tertius, or the tendons of the common extensor, to the anterior tibial, that the tendons were so small that, as the result of the suturing and necessary handling at the time of operation, sloughing frequently took place, and not only was the healing delayed, but the ultimate result more or less impaired. In the endeavor to avoid this the following operation was performed :

Through a straight incision three inches long, made longitudinally over the middle of the exterior surface of the leg, the muscle of the common extensor was dissected out and approximated to the anterior tibial muscle, and the two attached by means of quilted sutures. The attachment was made at the lower portion of the muscle, so that a portion of the tendinous expansion was included in the sutures; by doing this none of the contractile fibres of the muscles were impaired.

The wound was then closed tightly, and the foot and leg treated with a plaster-of-Paris bandage, the same as when the tendons have been directly attached. In this way the danger of sloughing is eliminated, and the contraction of the common extensor muscle necessarily exerts some of its powers upon the inner side of the foot through the anterior tibial tendon. In this case there has been some improvement, although not as much as I had hoped, and the operation is reported as one of interest rather than as one which is wholly perfected or for which much is claimed.

In conclusion, it has been found in a large number of cases of infantile paralysis, in which the thighs are involved, that the sartorius and tensor vaginæ femoris are frequently unaffected when all of the other thigh muscles are destroyed. Without the other muscles which assist and antagonize the sartorius in its normal action, this muscle, from its peculiar position and attachment, produces undesirable results in the use of the leg.

To overcome this and to make the greatest possible use of the muscle, five cases have been operated upon by the writer and here reported, in which the sartorius was divided at its lowest attachment, and reattached to the aponeurosis of the quadriceps extensor above the patella.

The result in three of the cases has been a marked improvement—in one almost the normal usefulness of the leg resulting. Of the two cases of failure, both were probably due to the failure of the stitches to hold, so that the desired union was not obtained.

One case is reported in which the anterior tibial muscle and the common extensor of the toes were attached in the lower part of their muscular structures in order to correct the faulty position of the foot.

